ON PERIODICITY OF GOOD AND BAD SEASONS.

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[With Plate V.]

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I FEEL some reluctance in coming forward to night, with the results of my investigations into the periodicity of good and bad seasons—floods and droughts if you will—because they must come to you as a surprise, and they will make a claim on your confidence, which at first sight you will probably not be disposed to grant. For myself, I know that some years ago, if anyone had come to me, stating that it was possible to forecast the seasons many years in advance, I should have received the statement with incredulity. It will not be a surprise therefore if you feel the same, but I hope you will give me a fair hearing before coming to a conclusion, so that you may have before you the evidence that has convinced me, and you can then form your own opinions.

I am not unaware of the fact, that there is a great gulf between having enough evidence to convince oneself, and being able to produce enough evidence to convince an audience, but the statement has not been made until there seemed to me to be evidence enough to convince anyone who will carefully weigh it. Moreover an endeavour has been made to put the evidence in such a form that it can be easily followed by all; to me it seems to be conclusive, but probably most of those who hear, will wait to be convinced by the result of the forecasts, and to meet this very natural feeling there will be to night a forecast of the seasons for the coming two years. The difficulty in getting the facts together has been very great, I have had to ask from history records of passing phenomena, which it has been the habit of the historian to neglect; however, there will be before you a mass of evidence in support of my proposition, ***that there is a periodicity in weather***.

The argument of my paper is, that if we take one hundred years of climate thoroughly studied, so that its salient features are clearly defined, and we compare this section of time with all past time, so far as the data are available, and find that the salient points in our century are repetitions of the salient points in all past time, and probably in all countries, then one is justified in coming to the conclusion that these salient points are definitely connected with the climate of the world, and will appear again regularly in the future. The weak point is freely admitted, viz., that history has not kept a regular and continuous account of droughts, but only recorded them when they became very prominent. The strong point is that all the data. that history does give us is in favour of the nineteen years' cycle.

In 1876 I read a paper before this Society on Meteorological Periodicity, and pointed out that, of many cycles discussed, one of nineteen years seemed to represent the seasons in New South Wales better than any other. Since that time the subject has been constantly before me, and no opportunity of putting together facts which might be useful in the further discussion of it has been lost. Scores of investigations have been carried out, some successful, others not so, in bringing forward evidence. My papers to this Society on " Floods in the Darling" and " Floods in Lake George," and the careful study of the rainfall and general weather and the diagrams of various weather records, barometer, thermometer, wind direction and force, and rainfalls of different Australian latitudes, from 1840 to 1887 have all been helps. All the usual weather cycles have been carefully studied, one that very many meteorologists accept, " Sun Spots," will be referred to later.

And it may be explained that the word drought is not used here in the sense in which it is often used in England and elsewhere, that is, to signify a period of a few days or weeks, in which not a drop of rain falls, but it is used to signify a period of months or years during which little rain falls, and the country gets burnt up, grass and water disappear, crops become worthless and sheep and cattle die.

There are parts of the world in which you never hear of drought but they tell you they have years of floods, and years of moderate rains, but nothing that can be called a drought, and yet

we have in these variations of the rainfall exactly the same causes at work, which make in another place a serious drought; that is, a variation in the annual rainfall, and in the temperature and winds; but one place has a superabundance of rain and does not miss a small quantity, while the other has barely enough at any time, and a slight variation makes a drought. The interior of Australia and many other places are of this character, and our coast districts have a fairly abundant rainfall which modifies the drought conditions, and relatively we have little drought. In other words a drought is nothing if it has not a suitable local setting.

Drought is however not wholly made by a shortage of rainfall. Its most important factors are great heat and drying winds. As an illustration we may look to the year 1895; in the latter part of winter and in spring, there were many falls of rain, which would have made grass in ordinary seasons, but it had no sooner fallen than a dry north-west wind and burning sun dried it all up. This great and burning heat was a well known feature in historical droughts, and some authorities say that the fable of Phaeton driving the Chariot of the Sun so close to the earth that he set it on fire, is a poetical setting of an actual experience in Greece when the sun became so powerful that the heat was almost beyond endurance.

THE DIAGRAM.

Before 1895 all the diagrams I used had been made to show quantities of the various elements, as well as their relation in time with a view to seeing if there was any periodicity. Recently it occurred to me that it would be useful to have a diagram in which all the droughts without regard to their intensity should be placed in their order of time; not only was this desirable for seeing what the relation in time was, but it had become evident that it would be impossible to see the relation between our droughts and those in other countries, unless some such pictorial arrangement was made. At the time it was not seen what a great saving of trouble and time this very simple device would ensure, but it is abundantly evident now, that this diagram has shortened by some years the attainment of the object I had in view.

As a preliminary to making the diagram, the particulars of the weather in this Colony from all sources, for every year of our history,

were carefully examined, and the years simply classed as good or bad, that is, having sufficient or insufficient rainfall; a form was then prepared with a vertical Space for each year, and across these a zero line was drawn to divide the good from the bad, and beginning with 1895 I filled in for that year, and below the line a convenient length of the column in red ink, the length was simply to catch the eye; then for 1894, a good year, I filled in with black ink† above the line a space equal to the red in the vertical space for 1895. The two years were thus contrasted, simply as good and bad; the question of how good or how bad was purposely left out. The diagram was then completed, each year being treated in the same way back to 1788. It was at once apparent that the drought which has been lettered **A** for convenience was the most regular in its recurrence, and the most extensive in time, lasting as it does from three to seven years.

† green ink in the diagram of this facsimile of Mr Russell's paper.

A vertical red line was then drawn through **A** between the first and second years, and it was found that the interval was regular and exactly nineteen years. In giving the date of any drought, the year after this line was used, being in all ordinary cases the middle year. Drought **D** was then examined and found to recur with nearly the same regularity, and a short vertical line was drawn under it to mark the point which has been taken as the centre, and this also recurs at intervals of nineteen years; there are three others, **B**, **C**, and **E** which also recur with an average interval of nineteen years, but they are not quite regular, may in fact differ from time to time a year or even two years, this uncertainty of time is indicated in the diagram by making the red space shorter.

The diagram takes in the whole period from the foundation of the colony to the present year, *i.e.*, one hundred and eight years, and it is certainly very noteworthy that the most pronounced droughts recur with such regularity, that is, at every nineteen years throughout the one hundred and eight years. It had been observed by me years ago that some of our great droughts had been world-wide, and when the diagram had got so far, it was decided to fill in the Indian droughts on a lower line, and see if they also coincided with Australian ones, and you see the result, viz., that in nearly all cases the great droughts in Australia had their counter parts in India.

The investigation had become interesting, and seemed to

promise to show the exact year of the great drought in this country, of which there was abundant evidence when the colonists landed here, both in the fact that to the south of Sydney all the very large trees were dead and between them were growing young trees; and the story of the blacks who said that the river Hunter dried up, that all the great trees died and most of the blacks, that those who survived had obtained drinking water from the mountain springs. A similar story of the drying up of the Murrumbidgee and their sufferings was told by the blacks on the Murrumbidgee. I had long wanted to find out when this terrible drought in this Colony took place, and the Indian record showed that the **A** drought had been repeated in 1769-70† which probably fixes the date: for the middle of the eighteenth century was very dry generally all over the world.

† 1769-70 represents a range of the *longitude of the lunar ascending node* from 270 deg. To 240 deg., here-after simplified to N = [270, 240]

A AND D DROUGHTS.

But, if we can carry the nineteen years period in this way back beyond our history, the idea immediately presents itself: "Where are you going to draw the limit: is there any limit?" It was evidently not a question for argument, but for proof or disproof by figures. It was recollected at the moment, that history records a terrible drought and famine in India in 1022, and there was a similar one in South America about the same time[1]. Does it lie in the nineteen years' cycle was the question which naturally occurred to me? And it was seen that it did, for 19 x 43 takes us back from 1838 to 1021, that is, to a repetition of **D** drought, and on the spur of the moment the differences of opinion about the accuracy of BC. dates was ignored and the figures were run out to see if the seven years famine in Egypt 1708 B.C. was in one of our nineteen years' cycles, and sure enough 19 x 186 + 2 takes us back to 1708 B.C., that is exactly the date of Pharaoh's famine; but Pharaoh's drought may for the present be discarded to appear again later; the fact that one famine in 1022, when dates may be taken to be reliable, should fall into the cycle was enough to suggest further investigation in reference to other recorded droughts, and all the records of droughts that had been collected in the last twenty years of general reading were tested to see if they fitted in.

1 Appendix No. 2.

Tables were prepared showing every date on which **A** drought recurred back to A.D.[2], and the same for drought **D**. I am not going to weary you by going through the list,1 but will give you the result. History says very little about droughts prior to A.D. 900, between that date and this, **A** drought has, on the assumption, occurred at every nineteen years. In this interval of nine hundred and ninety-six years there have been fifty-two repetitions of **A** drought, and the question is, what has history to say about its droughts. Well, it shows that these droughts have been repeated at various places on the earth on forty-four of the fifty-two dates 3 of these eight missing droughts, no less than six of them occurred between 1100 and 900 A.D., an interval when history was less complete on these matters. So far as I have gone history furnishes us with seventy-eight droughts in different countries, all of which fit into the series which we have named **A**. During the same period, **D** recurred fifty-one times, and history records droughts, numbering eighty-nine, on thirty-six of these periods. Taking then the droughts history has recorded between A.D. 900 and 1896 we have seventy-eight **A**, and eighty-nine **D**, a total of one hundred and sixty-seven, out of two hundred and eight on record ; but this is not all, for the drought **E** which is irregular in Australia, seems to be more definite and important in the northern hemisphere, and twenty-six more out of the two hundred and eight fit into **E** series making up the number to one hundred and ninety-three out of the total of two hundred and eight.

In estimating the importance of these figures, it must be remembered that North and South America, Russia, China, Persia, Turkey, Austria and Australia, before 1788, all subject to frequent drought, yet did not furnish to the numbers quoted more droughts than you could count' on your fingers, and it maybe fairly assumed that if we had these records, and especially if history had made a point of recording droughts, we should have had drought recorded on every recurrence of the **A** and **D** nineteen years' cycle, but I think the evidence, that history furnishes one hundred and ninety-three recorded droughts every

2 Appendix No. 1.

one of which fits into the cycle, justifies us in assuming that the nineteen years' cycle has been running for at least one thousand years, and may be trusted to continue and justify forecasts based upon it for some time to come.

Having got so much from a study of **A** and **D** in the Christian era, it seemed desirable to see if there were any recorded in BC. times and the following were found: one drought in Abraham's time given as 1920 B.C., does not fit into the cycle.

(1) Gen. xxvi. 1, in the time of Isaac, 1,804 B.C., 3,632 years before **A**; this interval is a multiple of nineteen years, *i.e.*, 19 x 181 + 3.

(2) Gen. xii. 54, Pharaoh's (seven years), 3,536 years before **A** = 19 x 186 + 2.

(3) II. Sam. xxi. 1, David's time, 2,849 years before **A** = 19 x 150 + 1.

(4) I. Kings xvii. 1, Elijah's drought, 2,736 years before **A** = 19 x 144.

(5) II. Kings viii. 1, Elisha's drought, 2,717 years before **A** = 19 x 143.

You will observe that the interval between (4) and (5) is nineteen years, between (3) and (4) is six times nineteen years, between (2) and (3) thirty-six times nineteen years.

For the convenience of having all the B.C. droughts together, we will bring forward from " Red Rains" the droughts which are therein found, and two from Roman and one Grecian history.

First then the Roman

(6) 493 8.0., drought at Rome, 2321 years before 1828 is in **A** series, interval is 19 x 122 + 3.

(7) 436 B.C., drought at Rome, thousands of persons threw themselves into the Tiber, to avoid death by starvation ; 2,264 years before 1828 is in **A** series, interval 19 x 119 + 3.

(8) 138 B.C., a drought over the world 1,976 years before 1838, is therefore in **D** series, interval 19 x 104. It is worth mentioning that in India from 503 B.C. to 443 B.C. there was great drought and pestilence, and these dates are in the **D** series.

(9) 503 B.C., great drought in India 2,341 years before 1838, interval 19 x 123 + 4. (**D**)

(10) 443 B.C., end of great drought, 2,281 years before 1838, interval 19 x 120 + 1. (**D**)

RED RAINS.

(11) 738 B.C., red rain in Rome 2,566 years before 1828, interval 19 x 135 + 1. (**A**)

(12) 652 B.C., red rain fell in Avis, 2,490 years, interval 19 x 131 + 1. (**D**)

(13) 650 BC. } parts of same drought as No. 12. (**D**)

(14) 648 BC. } parts of same drought as No. 12. (**D**)

(15) 626 B.C., red rain at Ceres 2,454 years before 1828, interval 19 x 129 + 3. (**A**) This rain was at the end of the drought.

(16) 587 B.C., rained blood in the campagna 2,415 years before 1828, interval 19 x 127 + 2. (**A**)

(17) 585 B.C., rained blood on one day in Rome 2,413 years before 1828, interval 19 x 127. (**A**) The beginning of the same drought as No. 16.

(18) 572 B.C., rained blood on the squares of Vulcan and Concordia for two days, 2,414 years before 1842, interval 19 x 127 + 1.

(19) 570 BC. The beginning of same drought as No. 18.

(20) 538 B.C., blood rain in Rome 2,376 years before 1838, interval 19 x 25 + 1.

We have in this list (omitting 13, 14, and 17) seventeen B.C. droughts, all of which with one exception, fit into our nineteen years' cycle. If these dates are examined apart from their connection with Australian droughts, we find that the intervals between them, are multiples of nineteen years, which shows, that droughts recurred then as now, in cycles of nineteen years, and this is very strong evidence in favour of our theory. The more so when it is remembered that all the BC. droughts I have been able to find, except one, do fit in ; they are not a series selected out of many, for the purpose of supporting the nineteen years period, but they are all that can be found. Again taking the dates given in history, the intervals between these B.C. droughts and ours in Australia are multiples as we have just seen of nineteen

years.

If it be objected that chronologists have grave doubts as to the accuracy of B.C. dates, I reply that whether they be correct or not, it is quite certain that historians did not purposely arrange the dates in order to make them fit into a cycle, running amongst these droughts, that was unknown to them, or to make them fit into the Australian cycle, which had not even been discovered.

These drought dates are well marked points in ancient history, and the fact that they fit into a cycle,supported by all the known droughts of the last thousand years of the world's history, is in strong confirmation of the accuracy of these B.C. dates.

The figures show that Elijah's prediction was a repetition of Pharaoh's drought 42 x 19 years after it; also Elisha's prediction was nineteen years after Elijah's, and it is noteworthy that the drought in David's time, although it does not appear to have been predicted, was 19 x 36 after Pharaoh's. This seems to me to be very strong evidence in favour of the view that the Egyptians knew of the nineteen years' cycle, and that the Jews brought the knowledge away with them.

Those learned in Assyrian antiquities tell us that the book containing "the Observations of Bel," the oldest astronomical book of that part of the world, was ordered to be kept by the king of Saros 3,800 years B.C.; that book shows that they kept a record of astronomical and all other events, that they had discovered the nineteen years' cycle of eclipses, and we are told that they believed that one event caused another, and all astronomical and meteorological observations were thus bound up together. Under such conditions I do not think it would be possible for them to avoid finding in the droughts a similar period to that in the eclipses, via, nineteen years, but even if they did it would have been impossible for those who kept the Nilometer in Egypt to avoid finding it in the variations of the heights of the Nile floods which were of such vital importance and so carefully recorded.

Having got so far, I looked for any droughts mentioned in Roman history, to see if they would coincide like the others with the nineteen years' cycle, and found two, one in 493 and the other in 436 B.C., in both cases these are repetitions of the **A** drought, but the historian has quoted the end of the drought for they

are three years after my date, which is the second year of a drought that lasts from four to seven years. History tells us that in 138 B.C. there was a drought over the whole world, and the heat is said to have been excessively great: this intense heat, is one of the most marked feature of a **D** drought today; witness the excessive temperatures of January last, and the record temperature of Australia 127° at Bourke, was nineteen years before in 1877; while intense heat was a feature of January 1858, scorching heat of January 1839, and intense heat February 1820; such is the **D** drought series in Australia.

We thus see that five out of six Scripture droughts fit into the nineteen years cycle, two from Roman history, and one from Grecian, and nine from red rain, in all seventeen B.C. droughts, agree in supporting the cycle.

The evidence of these droughts is very strong because it is so nearly unanimous; and, as we shall see presently, it receives support from an unexpected quarter. In passing, I may mention that the interval between the dates four hundred and ninety-three and four hundred and thirty-six is fifty-seven years, or three times nineteen.

RED RAIN.

Since I have been working at this subject there have been a number of red rain storms noted in this Colony, and the latest on April 10, suggested to me this line of investigation. Red dust is obviously a proof of drought somewhere, otherwise the dust could not rise, and since these proofs of drought are entirely apart from the others, and recorded not as droughts but as prodigies, which in days gone by created no little alarm; it will be worth while to see how far they support or contradict the nineteen years cycle. The result of this resolution came as a surprise to me because it was so unexpected, I had no idea there were so many records of red rains, or that they so strongly supported the nineteen years' cycle.

There are altogether sixty-nine recorded instances of the fall of red rain, of these I have recorded six for New South Wales. The first historic red rain was fourteen years after the foundation of the city of Rome, that is in BC. 738, and there are nine others B.C., all of which fit into the nineteen years' cycle; between 538

B.C. to 582 A.D. I can find no record of red rain, but from 582 to 1896 there are fifty-nine recorded falls of red rain, and all of them fit into the nineteen years' cycle. We have here then nine B.C. droughts which go with the eight mentioned before to make seventeen B.C. droughts in support of the cycle, the remainder, fifty-nine, are included with a few exceptions in appendices Nos. 1 and 2.

HURRICANES COME IN DROUGHTS.

I should like it to be clearly understood that I do not mean ordinary hurricanes which are as much parts of ordinary weather conditions in some parts of the world, as our southerly winds are here. What I mean are extraordinary hurricanes, those that came at long intervals to terrify mankind by their power for destruction. These are connected with droughts, and therefore should be discussed here. I had years since observed that the connection between the two was obvious enough sometimes, and during the past year I was reminded of it very often by the frequent reports of heavy gales met with by ships coming to this port, indicating great atmospheric energy. Then on March 24, 1895 occurred the worst gale of the Nineteenth Century in England, which did more damage there than any other gale since 1703. Then on January 3, 1896, came the hurricane over the Tongan group of islands, and not one of the vessels in the harbour rode out the storm; every one of them was wrecked before morning, and the wind was of such exceptional violence that after it was over, the islands looked as if they had been bombarded.

And as I write, May 28, we have the report of a terrible cyclone in America, by which three of the States, Missouri, Illinois and Indiana were damaged, the city of St. Louis was wrecked, and 1,500 people killed by falling buildings, and damage to property caused to the extent, as estimated, of twenty millions of dollars; this is another fragment of the present **D** drought.

Then I turned to storms on this coast, some of which were of terrible violence.

DANDENONG GALE IN DROUGHT D.

And as I looked, memory ran over the storms of the past and picked out the most terrible gale of which we have any record in Australia, viz., the Dandenong storm, on 10th of September, 1876, just nineteen years before 1895, a storm in which a very fine steamer the "Dandenong," going to Melbourne foundered, and all hands were lost. In parts of this storm gusts of wind reached one hundred and forty and one hundred fifty-three miles per hour.

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CAWARRA IN DROUGHT A.

Then the "Cawarra" Gale, a most furious easterly storm in which this fine steamer was wrecked at the entrance to Newcastle, N. S. Wales, on July 12, 1866, in the great drought period which we have called **A**.

DUNBAR IN DROUGHT D.

And on going back another step, I remembered the loss of the "Dunbar" at Sydney heads, in a tremendous easterly gale, on 20th August, 1857, just nineteen years before the "Dandenong" was wrecked. It is not my purpose to describe these wrecks, I only recall them as the most memorable that our short history affords,and the fact that they all occurred in our great drought periods, set me searching history to see if great storms and droughts had any connection.

That there is such a connection seems, a priori, extremely probable, because the great heat that accompanies a drought furnishes that additional impulse to the circulation of the wind which is necessary to urge it into violent storms; for a comparatively small additional impulse over the large area of the equatorial regions, would supply the energy necessary for these very violent local storms. The heat is a matter of common observation, and the hurricane at such periods is found by the careful observer to be something unusual, and possessed of a restless energy in drought times. It was soon found that the conditions observed in a few cases of my own experience were amply confirmed by a search which was carried back for six

hundred years. Sixty-two hurricanes were found, the greater majority being between 1700 and the present day, and only exceptionally violent hurricanes were selected, such as are quite distinct from the ordinary hurricane or storm, and when these came to be compared with the drought periods it was found that every one had occurred in a drought year ; and further, that those of the greatest violence belong to the **D** drought, which is remarkable for its great heat and the energy of its winds.

GREAT FROSTS.

Another interesting series of phenomena connected with droughts I find in the great frosts of Europe—the absence of cloud in these seasons, due to the dryness of the air, permits of extreme radiation at night, and hence great cold is frequent in drought winters, as heat of unusual severity is experienced in the summers,and it is another proof of the hold these drought periods have on the weather. But let us turn to the lists of the great frosts of Europe, collected by the celebrated astronomer Arago—they were not collected for the purpose I am going to use them, but he selected all of them from ten centuries of European records—as there are only sixteen in a thousand years, it is safe to assume they were of exceptional severity ; and they are so beyond question. Our present purpose with them, however, is to see whether they support in any way our theory.—Eleven of them fall directly into the **A** drought, three of them fall directly into the **D** Drought, and three into one of the minor droughts lettered **E**.

806, the Rhone was frozen over, (end of a long **A** drought)

833, the Po was frozen over from Cremona to the sea (**D**)

1234, loaded waggons crossed the Adriatic on ice in front of Venice (**E**)

1305, all the rivers of France were frozen (**D**)

1324, people travelled from Denmark to Lubeck and Dantzic on the ice (**D**)

1334, all the rivers in the South-east of France and all those of Northern and Central Italy were frozen and the frost

lasted in Paris two months and twenty days (**A**)

1468, it was necessary to break up the wine in Flanders with hatchets in order to serve it out to the soldiers, owing to the intense cold (**A**)

1544, the wine in France frozen; had to be broken up before issue to the soldiers (**A**)

1594, the Mediterranean was frozen over from Marseilles to Venice

1657, the Seine was completely frozen over (**A**)

1709, the Adriatic and the Mediterranean were frozen over 1717, shops were established on the Thames (**A**)

1742, the Seine was entirely frozen over (**A**)

1744, Seine entirely frozen over (**A**)

1766, Seine entirely frozen over (**A**)

1767, Seine entirely frozen over (**A**)

1895, the Thames frozen over (**A**)

(**A**) eleven, (**D**) three, (**E**) three.

THE DEAD SEA.

One finds it commonly stated in books that the Dead Sea is gradually drying up and perhaps it is, but there are very considerable alterations in the level of it; for instance Lieut. Conder, when surveying Palestine, June 1872 to June 1875, found it did change its level considerably, and at page 220 of "Tent Work in Palestine," he states, "Sheikh Jemil, the most intelligent Arab near Jericho, told me that in his father's time the sea did not generally reach further inland than the Rujum el Bahr. Whereas now the connecting causeway is always under water. This represents a rise of some ten feet in the water level. In fact according to this statement, the sea had now (1873 or 1874) more water in it than it used to have half a century ago."

From this it would seem more than probable that the Dead Sea followed the same course as Lake George, where the water

gradually disappeared after 1826, was all gone in 1838, and remained only a shadow of its true self until 1852, when it began to fill up, and in 1874 attained its maximum flood. Lake Titicaca followed much the same order. So that we have here lakes in Asia, South America and Australia, drying up in the great droughts of 1828 and 1838 and during the small rainfall of the whole period 1825 to 1851, and filling up after that year.

EGYPT.

Mr. Anderson, Principal Librarian of the Public Library, has given me very cordial assistance in my search for particulars of the climate of Egypt, and, as a consequence, I found in the works he brought under my notice records of droughts, or, as it is there termed, "low Nile" on nineteen years. Five belong to **A** drought in our cycle, and twelve belong to **D**: that is seventeen out of nineteen correspond with dry periods in New South Wales, and the other two correspond with one of our minor droughts; and I see that, in Egypt as in England, their weather change comes about a year before ours in Australia.

BREAKS IN DROUGHTS.

It is not my purpose to night to go into the details of the life of a drought; I am writing to try and prove to you that there is a cycle which rightly understood will be of the utmost value to this Colony. At another time I have to go into what might be called the personal history of a drought; but there is one feature of their history that bears so strangely upon their periodicity, that I cannot defer it, although this matter more correctly belongs to their personal history: I refer to their sudden interruption by violent rains extending over small areas; you will see in what follows that this is a feature that comes in a certain month in each series **A** and **D**, and for the moment seems to break up the drought, but the drought nevertheless returns to complete its full course.

This break is a well-marked feature of droughts, and one that is very apt to, and very frequently does, mislead those who do not study the drought as a whole. A very good illustration of this has been before us quite recently in this **D** series. A very heavy

rain storm came on in February, 1896, in the north-western districts, as much as ten inches falling in a single night in some places. But when one comes to look carefully at the character of the rain, we find that the most marked feature of it is that it is not general, but made up of a series of violent local storms, each confined to small areas, but widely separated from one another, and connected only by comparatively light rains; and, further, that these storm-bursts, as they are sometimes called, discharge the rain so rapidly that it has not time to sink in, but runs away to the nearest water-course, and therefore, fails to do that amount of good which we should expect from the quantity measured.

Unfortunately, one cannot, as a rule, learn the area of these storms, but many circumstances, such as the absence of the same heavy rain at neighbouring stations indicate the fact, and sometimes they cover only a small part of one station. I may illustrate what I mean, both as to the area covered by the rain and the immense quantity that comes down, by the experience of a friend, Mr. L. S. Donaldson, in 1869, on page 86.

One of the most remarkable and best known rain storms inland occurred in the end of January, 1885, when we were right in the middle of 𝔸 drought. The storm came in at the north-west corner of the colony, and travelled thence in an east south-east direction, straight across New South Wales to the sea, depositing from six to eleven inches in a day and a half as it passed on. From the central line of heaviest rain, which passed over Wilcannia, the quantity of rain fell off rapidly, so that at Bourke the river rose only four feet, while at Wilcannia it rose twenty eight feet; but the rain messenger having made his way over the colony, drought again took possession, and it did not break until the middle of the year 1886.

Just nineteen years before this storm of 1885, a very similar storm passed over Bourke in January, 1866 (again in **A** drought); very heavy rain fell, but the river did not rise much, although the rain lasted two days, showing that the rain area was small. Nineteen years before this there is no record (*i.e.* in., 1847) of what took place in the then unoccupied Darling Country, but it is worth mentioning as evidence so far, that there was such a storm in the West, that an exactly similar storm passed over the Paterson River on January 17th, 1847, just as the

one in 1885 passed over Lake George and deposit eight inches of rain there; at the Paterson, it rained so heavily during the day that the river rose higher than it had been for some years before.

I have already alluded to the recent (February 1896) rain storm over Bourke and the Bogan country and its remarkably patchy character. It is worth while adding that it is evident from the few records available (only two stations west of the Darling) that a similar storm occurred in February 1877; for in February "Momba" Station had a storm and four inches of rain, and "Yancania," seven and a half inches in the same month, nineteen years before that of the present year 1896. In 1858 no one on the Darling River thought of rainfall records, and the few notes left by those who were taking up the country there do not help us at. All ; but Dr. Glennie's record at the Paterson again comes to our aid and tells us that on February 2nd, 1858 a most tremendous rain and hail storm with thunder and lightning passed over the Paterson. I mention these peculiar rain storms just to show how they repeat themselves as notable parts of the weather at intervals of nineteen years, and it is to be noted that in **A** droughts the storm came in January, and **D** series in February.

But it is not alone in these storm rains that these features of drought are repeated, it shows in many ways and not least in temperature; for instance, we all remember the intense heat of January 1896, when one hundred and sixty deaths were attributed to the great power of the sun in the Bourke district, we find intense heat occurred at nineteen years' intervals before that in January 1877, 1858, 1839, and 1820; in 1839 it was so severe that the vines, grapes, and leaves were burnt up; the latter crumbling to the touch as if they had been baked.

I will add just one more because it is in a short sharp drought which only lasted a year and finds its type in 1888. In that year on February 8th, a very heavy rain storm accompanied by thunder and lightning came into the Colony from the north, and reached Moree at 7·45 p.m. on that day; so heavy was it that the whole of the surrounding country was flooded, and the local rain caused a rise in the river of ten feet. It Spread over the Namoi, Macquarie and Bogan Rivers, but did not go south of Dubbo. Just nineteen years before in February 1869, Mr. L. S. Donaldson, P.M., who was then living on the Bogan, tells me that

the February 1896 storm reminded him of a heavy flood rain in the former year. It was, he says, " not so extensive as the recent ones, but on that occasion the rain fell at Moonagie, near Cannonbar ; the River Bogan was dry throughout its course, except a waterhole at long intervals. The rain fell over only about a mile and a half of the river, and for only about one hour, but such a quantity of rain fell (we had no rain gauges then) that the river ran for seventy miles, into the long waterhole at Gongolgon. The rain was accompanied by large hailstones, which went through verandahs, and killed emus and kangaroos, and stripped all the "leaves off the trees till they looked like English trees in winter."

GOOD SEASONS.

Looking at the diagram, we find that there are as many good seasons as bad ones. Some of these recur with great regularity : for instance, the two years immediately before the commencement of **A** drought, and likewise the two years immediately following **D** drought. Then there are three good years together that come as a rule four years after the centre of **A** drought ; their regularity is made uncertain by the irregularity of the end of **A** drought.

Before A.	Following A.	Following D.
1787-8	1794-5-6	1802-3
1806-7	1813-4-5	1821-2
1825-6	1832-3-4	1840-1
1844-5	1851-2-3	1859-0
1863-4	1870-1-2	1878-9
1882-3	1889-90-1	1897-8

In 1893 we had the lowest grass temperature on record, and a very wet year on the coast although inland it was dry. The series runs—on the coast—

1893, heavy floods, lowest grass temperature on record.

1874, many heavy floods.

1855 no record of this year.

1836, abundance of rain, snow fell in Sydney.

1817, high floods on the coast and inland.

1798, "wet, and in July uncommon cold."

It thus appears that good years precede and follow great droughts in the cycle, and while **D** carrys its heat and its winds with it. The 1893 series carries its floods and its low temperatures.

I have thus endeavoured to put before you some of the reasons which have convinced me that there is a cycle in weather, but the necessity for brevity in order to keep the proof within the limits of one address, has rendered it necessary to express in a few sentences the results of many separate investigations, and the evidence does not seem so strong when thus condensed, as it does when a number of facts one by one are brought to light from diverse sources, all of which individually support the proposition. I can assure you that the evidence was far more convincing when taken in detail, but want of time to get these details into one address, make this course impossible. Enough appears to have been said to prove that the cycle does exist, and to show you the very great importance of this rediscovery of a law of climate, which, there are many reasons to think was well known to the Jews, the Egyptians, and other ancient peoples; they at least knew how to forecast droughts successfully, and in Egypt, like sensible people made provision for them. We have in the diagram, the weather of one hundred and eight years of New South Wales climate, arranged in order of date (the intensity being for the time overlooked); the black spaces above the line represent the good years, while the red spaces below the line represent the bad years. It is evident upon inspection that certain features of it recur every nineteen years; we have seen that the droughts of history, the great and conspicuous droughts I mean, all drop into this same cycle: both those that happened before the birth of Christ and those that have occurred in our era.

We have seen that great hurricanes, the great frosts of history, all the red rains, and all the droughts that history records, with a very few exceptions, are likewise included in this cycle, and that

the level of great lakes in Palestine, South America, and New South Wales, are subject to the same mysterious influence that controls our weather, and a search for the cause has not been forgotten.

THE CAUSE OF DROUGHTS.

As my investigation proceeded, the weight of evidence gradually converged upon the moon as the exciting cause. I have never had any sympathy with the theory of lunar influence upon weather, and received, rather against my will, the evidence that presented itself, but the logic of facts left no alternative, but to accept the moon as prime motor. There has not been time to complete this investigation, and when finished it must form another paper. Meantime I may say that so far the comparison of the moon's positions in relation to the sun and earth and droughts shews that when the eclipses congregate about the equinoxes, that is in March and September, they do so in the years which give us great droughts, the **A**s and **D**s of our series. Further that when the eclipses accumulate in February and March, that is at the vernal equinox, and the month before it, and September the autumnal equinox, and the month before it, August, We have the more intense and relatively shorter **D** droughts, with heat, gales and hurricanes; on the other hand, when they accumulate about March and April, that is the month of equinox, and the one following, and about September the month of equinox, and October following it, we have **A** droughts, that are less severe, but much longer than the **D** droughts. But I must stop for the present. I have already pointed out the use of the diagram, and a. few words in reference to it will close what I have to say tonight.

I have spoken chiefly of droughts, but so far as our own history is concerned it would have served the purpose just as well if I had taken up the periodicity of wet years, but outside Australia it would have been very difficult to get the necessary data, for history has much more to say about the horrors of drought than the abundance of wet seasons. The diagram presents one fact that will be of interest to many in this droughty time, it is the forecast of good seasons in 1897 and 1898.

SUN SPOTS.

For convenient reference, I have put on the diagram the maxima and minima of the sun spots. You will see at once that the recurrence of the period is very far from being the regular eleven years cycle which many persons suppose it to be, and it is equally far from being in accordance with the cycle that I have endeavoured to demonstrate to-night.

APPENDIX I.

Year.	List of Droughts of the A Series.
1885	1886, great drought in Texas; grass completely destroyed, calves nearly all dead; 180,000 head of cattle on the move; estimated loss so far (Sept. 1886) $3,000,000. (Evening News.) 1886, drought in Ireland for past three years. (Mr. Pollock.) The *Scottish Agricultural Gazette*, March 1886, says, the losses in stock in the Argentine Republic have been exceptionally heavy, no less than 70% of the cattle and sheep on some estancieros having perished; the estimated loss in sheep in the Republic is 5,000,000 since this time last year.
1885	France. Rainfall has been below the average in almost every month since January 1883. (Journal of Science, Feb. 1885, p. 116).
1885	This drought in New South Wales was considered to be the worst since 1837-8. The estimated loss of sheep alone was nine millions. The Darling at Bourke was below summer level seventeen months out of the two years 1884-5, and during the other months never rose more than ten feet. Even on the coast, the Paterson River had become a chain of water holes in February 1884.
1885	Red rain fell in December 1883; in February and again in March, 1884 3 in August 1885. A proof of the intensity of this drought.
1866	Great drought in Bengal and Orissa; one and a half millions of people died from starvation. (*Journal of Science.*)

Year. **List of Droughts of the A Series.**

In Mauritius from 1861 to 1868 the rainfall was less than during any similar period, so far as can be ascertained since the discovery of the island. (*Physical Geography*, p. 171, *Laughton*)

Bousingaut wrote, "The table lands of New Grenada at an elevation of from 6,500 to 9,000 feet. The village of Dubati is situated near two lakes, which were united in 1807; the inhabitants had witnessed the gradual subsidence of the waters, in so much that lands which in 1837 were under water are now 1867, under cultivation." (*Smithson. Rep.* 1869)

1864 Drought in Russia.

1846-7 Great Famine known as Potato Famine in Ireland. 1847, great drought in South Africa. (I pp. 1718, *South Africa.*)

Red rain 1846, and again 1847.

Very severe drought in New South Wales.

Great drought in England 1845 and 1846.

1828 1827, great drought in England which lasted two years.

1826, great heat and drought in Europe. (*Herschel ,Metr.*)

1826, the late drought in Russia caused a rise in the price of flax. (*Climate N.S.W.*, p. 95.)

1827, "on the Pampas and the Chaco of La Plata these droughts produce the most remarkable results with regard to the distribution of animals. In the drought of 18278-9 the drought still spoken of as "*Il gran seco*," the destruction of life was enormous, not only amongst the cattle, but also amongst wild beasts, of which last, indeed some species were altogether annihilated." (*Laughton, Phys. Geography*, 13-154)

Year. **List of Droughts of the A Series.**

1828 "During this time (*i.e.*, 1827-28-29) so little rain fell that vegetation even to thistles failed. The brooks were dried up and the whole country (the Pampas in South America) assumed the appearance of a dusty road. This was especially the case in the northern part of Buenos Ayres, and the southern part of "Santa Fé" very great numbers of birds, wild animals, cattle and horses perished from want of food and water. The lowest estimation of the loss of cattle in the province of Buenos Ayres alone, was taken at one million head." (*Laughton, Phys. Geography*, p. 33.)

1809 The intense drought of 1811 in Europe was accompanied by hurricanes and earthquakes. (*Eng. Mechanic*, Vol.XXXIX., 1884, p. 507, quoting an Italian savant.)

1812, great drought in Venezuela, not a drop of rain had fallen at Caracas or within two hundred and fifty miles of it for five months before this. (*Boschovish on Earthquakes*, p, 131.)

1790 A great drought in 1790-2 in "Baroda," India and some adjoining districts. (*Ency. Brit. et Journal of Science*, 1878.)

1771 "During 1769-70 the great drought in India killed three millions of people. In 1770 the heat in India was so terrible that many persons died of asphyxia (?heat apoplexy) others saved themselves by going into caves and pits." (*Eng. Mech. Jour. Sci.*) Mulhall, *Dic. Dates*, says "this was considered the worst drought of modern times."

1752 Drought in India 1745 to 1752, in 1753 many died from excessive heat. Temperature 100° to 104°. (*Walford.*)

1733 Great drought in the north-west provinces of India this year.

1714 Exceedingly hot and dry in England 1716. (*Walford.*)

1695 1693, an awful famine in France. 1693-4, hot drought in Italy.

1676 1678, hot and dry throughout this year in England. (*Walford, Journal of the Statistical Society*.)

Year.	List of Droughts of the A Series.
1657	Scorchingly hot and dry in England. 1657-8, drought and famine in Rome.
1638	1637-8, hot and dry in England. Red rain 1638 and 1640.
1619	1616, exceedingly hot and dry in England. (*Walford.*)
1600	1601 to 1603, great drought and famine in Ireland. Same in England. Great drought in Russia.
1581	Drought in Persia. Red rain 1580. 1583, excessively hot and dry in England.
1562	1563, drought and pestilence in India, carried off 20,000 people.
1543	A wonderful drought in England. 1540 to 1543, three years drought in India.
1524	Severe drought in England.
1505	1503, great drought in England.
1486	Great drought in England.
1467	No record.
1448	1447, great drought in Ireland and England with heat.
1429	Drought in Scotland.
1410	Great drought in the delta of the Ganges India 1412-13.
1391	Great drought for two years in England.
1372	No record.
1353	1352-3, great drought and famine in England, France, and Italy.
1334	1332, drought in Ireland.
1315	1316, drought in England, grain was so scarce that there there was none to make beer.

Year. **List of Droughts of the A Series.**

1296 1294, universal drought in England.

1277 1280, drought in England for three years. 1277, all the largest rivers in Europe shrank to the tiniest rivulets owing to drought. (*Eng. Mech.*Vol. XXXIX., p. 506).

1258 1259, droughts in England. 1260, the Rhine, the Seine, the Po, and the Tiber shrank to the tiniest rivulets owing to drought. (Italian Essay—*Eng. Mech.*Vol.XXXIX., p. 506.)

1239 Great famine in England, people eat their children.

1220 No record.

1201 Drought in Egypt. (*Modem Egypt*, p. 115)

1182 Red dust 1181. Red dust 1184.

1163 Red dust ; drought and famine all over the world.

1144 Drought during all harvest and long after in England.

1125 1123-4, terrible drought in France and Germany.(*Walford*)

1106 Drought in England. (*Walford*)

1087 No record.

1068 1064, drought in Egypt for seven years. (*Modern Egypt*.) This is probably **E** united to **A**.

1049
1030 } No record.

1011 1012, drought in England and Germany.

992 993, vegetation was burnt up by the sun as if by fire. (Eng. Mech, Vol. XXXIX., p. 506.)

973 975, the great famine of Paris.

List of Droughts of the A Series.

Year.	
954 935 916	} No record.
897	The water supply of Italy, France, and Germany was entirely dried up by drought ; vast numbers of peasants were struck down by the intense heat of the sun. (Eng. Mech, Vol. XXXIX., p. 506.)
764	762, long and terrible heat, Britain ; 767, great drought in Asia. **A** and **B** united.
645	Great drought in England.
479	480, drought in Scotland.
460	No record.
441	439, drought in Britain.

APPENDIX II.

Year.	List of Droughts of the D Series.
1895	Drought in New South Wales.
	Red rain, April 10, 1896. Drought in England.
	1894, a terrible drought in Antigua, West Indies.
	1896, farmers in Spain are being ruined by protracted drought. (*Sydney Morning Herald.*)
	1895, drought in Norfolk Island.
	1896, excessively high temperatures in India.
	1895-6, drought in China about Honkong. (*S.M. Herald*.)
	1896, Jan. 8, South Africa, no harvest to speak of for three years, no grass, no water, and the rainy season over, so that there is no hope of rain until April or May.

Year. **List of Droughts of the D Series.**

1876 Drought in West Indies, Guinea, Venezuela, Columbia, and Brazil.

1878, United States, excessively high temperatures 90° to 110° ; in Canada 90° to 103°, at Milwaukie 103 cases of sun stroke, at St. Louis 1,500 cases of sun stroke.

Drought in India 1875-6-7, half a million of people died, Madras, Mysore, and parts of Bombay. "Madras, Oct. 17, 1876, the state of Kurnool, Bellary, Cuddapah, North Arcot, and Chingleput districts, and also Mysore, is alarming, owing to the drought. In the Bombay Presidency six millions of people are threatened with famine by the failure of the monsoon rain. Relief cost £9,000,000. (*Jour. Sci.*)

1878. great drought in Barbary.

1876, severe drought in Spain.

1876, drought in Samara, Eastern Russia.

1877, June 18, "China," "Chihle," and "Shantug" districts containing many millions of inhabitants, the harvest had failed for two years running, neither grain nor food were to be had at any price ; the whole country seems to have been scorched by a burning wind ; people eat every bit of grass, or bark or leaves or trees that they could find, and to avoid death by starvation, committed suicide. In Chefoo it is stated on good authority, that human flesh was actually offered for sale in the shops until prohibited by the mandarins.

1877, in Southern California there was a total failure of crops, and millions of sheep died.

Year. **List of Droughts of the D Series.**

1876 "Cape Colony, Australia, South Sea Islands, and it would appear almost every known portion of the Southern Hemisphere have been suffering from severe and protracted drought. In Australia shade temperatures of 124° and 127° are reported; sheep cattle and horses and wild animals of these regions are dying off in thousands." The heat in the east of Cape Colony during January 1878 is described as the most disastrous ever known in that region—*Nature*, Vol.XVII., p. 436.

(Goldsbrough & Co., estimated that in Australia the loss of sheep alone at nine millions in the 1877-8 drought; to this has to be added the losses of wool, cattle, horses and farm produce; Sir James M'Cullock, estimated the loss on the sale of wool alone at £2,000,000).

1876 In Cape Colony (*Nature*, ibid.) complete ruin has overtaken a large number of the settlers, many of the homes of hitherto well to do colonists have been broken up, and the several members obliged to go into menial service in exchange for the barest necessaries of life.

In the South Seas we find the same dire effects of the 1876-77 drought; it began in 1876 and lasted all 1877, many of the natives died of starvation, so severe was the drought. The Rev. S. J. Whitmee writes, "we have had the greatest drought I have ever known." In Tanna, New Hebrides, the crops completely failed and many of the people died of starvation.

In the Island of Ascension there was no rain for fourteen months before August 1877, and the supply of fresh water for each person had to be reduced to one gallon per day.

In Egypt in 1877 they had the lowest Nile on record, a proof of the severity of the drought at its source.

1857 Drought in India 1856-7.

Admiral Fitzroy states that in 1858 and 1859 drought Prevailed in Africa, America, West Indies and Australia, 1857-58 drought in England did not break up until Sept. 1859, but in South Africa and Australia it broke up before that.

Year. **List of Droughts of the D Series.**

1838 1837-8-9, severe drought in parts of the north-west provinces of India; 800,000 people died.

January 1839, weather scorching hot in New South Wales, River Cowpastures New South Wales dried up, not as much rain the past two years as would suffice for two months. Murrumbidgee also dried up. The drought in Australia during 1837-89 was one of the worst ever known here. Red rain in 1839.

1819 Great drought in Germany 1821, all vegetation parched up and even the rivers dried up.

England 1819, very hot and dry, no rain fell for 74 days.

New South Wales suffered considerably from drought 1818-19. 1821, red rain fell.

1800 Drought in New South Wales.

1781 1781-82, drought and famine in Madras and Carnatic in 1872-3 drought in "Sind," no rainfall for two years.

1783-4, drought in Punjaub during these years.

1779, excessive heat at Bologna, many died of sunstroke, and many others to escape the heat, took refuge in pits and caves underground. (*Eng. Mech.*, Vol.XXXIX., p. 506.)

1762 1763, red rain.

1743 Red rain 1744.

1724 No record.

1705 1704, the hottest and driest summer in England, continued to August 1705.

1705, the temperature rose so high in Europe that it resembled that of a glass house furnace, and butcher's meat was cooked in the sun, and from midday to 4 p.m. no one ventured out of doors. (*Eng. Mech*, Vol. XXXIX., p. 506.)

1686 Red rain fell in 1689; 1684 was a very dry year in England. 1686, great drought in Italy.

List of Droughts of the D Series.

Year.	
1667	1666, hot and dry easterly winds in England ; 1669, the whole year was hot and dry in England. Red rain fell in this year, 1669.
1648	No record.
1629	1630, drought in England ; 1631, drought and famine in India and throughout Asia.
1610	Excessive heat and drought in England ; red rain fell.
1591	1590-92, extreme heat in England with plagues of insects.
1572	Red rain fell 1571.
1553	1551 to 1554, in England they had scorching hot and dry summers.
1534	No record.
1515	1516-17, hot and dry in England.
1496	1498, very great drought in England.
1477	Great heat and drought in England.
1458	No record.
1439	1437, wheat sold in England for six times its normal price.
1420	Red rain, March 1422.
1401 1382	} No record.
1363	1361, very grevious drought in England.
1344	1344-5, all Hindustan suffered from drought and famine.
1325	No record.

Year. **List of Droughts of the D Series.**

1306 1303-4-5, protracted drought in Europe, in so much that the largest rivers of Europe, the Rhine, the Seine, the Po, and the Tiber, all shrank to the tiniest streamlets. (*Eng. Mech.*, Vol. XXXIX., p. 506.)

1287 1285, great and sudden darkness, then such drought and and heat as killed most grain in England.

1288, heat and drought so intense that it killed many persons.

1154 1152, very dry and cold, followed after harvest by greatest heat and drought.

1135 1135 and 1137, great drought in France and England. In 1132 the earth was so burnt up by the intense solar heat that that great fissures appeared in it miles long. (*Eng. Mech.*, Vol. XXXIX., p. 506.)

1116 1113, England so hot that corn and forests took fire. Red dust 1117.

1059 Famine in Egypt in 1859 (*Eng. Brit. Fam.*)—in Modern Egypt the date is given as 1064. Rise in river failed for seven consecutive years ; in two provinces half the people died. (**B** and **E** combined.)

1040 No record.

1021 Excessive heat and drought in England. 1020, great drought in India, and in Central America it lasted six years.

(*Abbé Brasseur de Bourbourg*—"*History of the civilized nations of Mexico and Central America*," Paris 1857.)

1002 1000, the wells, water courses, and lakes were all dried up. (*Eng. Mech.*, Vol. XXXIX., p. 506.)

869 Red dust 869.

850 850 to 851, drought in Italy and Germany.

774 775, drought and excessive heat in England after great frost. 772 great drought in Ireland.

Year.	List of Droughts of the **D** Series.
755	No record.
736	737, great drought in Britain.
679	680, drought in England for three years.
603	605, drought and scorching heat in England.
584	Red rain fell.
451	Great drought Eastern Europe, Phrygia, Galatia, Cappadocia. This was probably an extension of **D** into **E**.
375	374, drought and famine in England.
299	298, great drought in Wales.

DISCUSSION.

Professor GURNEY said:—Though neither astronomer nor meteorologist, I should like to offer a few remarks on Mr. Russell's paper, taking points in order, as they strike me. In discussing the weather of this Colony, Mr. Russell says, "The years were simply classed as good or bad, the question of how good or had was purposely left out." What is Mr. Russell's definition of a good year or a bad one ? He has apparently thrown over his rainfall and temperature statistics, and his bald statement that such-and-such a year was good or bad seems far from convincing. I am afraid that the diagram which he shews us to-night, based upon these statements, is useless, if not misleading. I object also to another detail in the diagram. Mr. Russell "draws a vertical red line through **A** between the first and second years." He says that the interval "was regular and exactly nineteen years." Also this so-called **A** drought varies in its length, "lasting from three to seven years." It follows that a line drawn so as to mark the middle of an **A** drought would not have recurred at equal intervals of nineteen years. Yet the middle seems to me a more natural datum line.

Again, periodicity cannot be shewn by picking out a drought in Egypt, another in India, and a third in Australia, all happening at different times. Mr. Russell distinctly lays down as his thesis "the salient points (in the weather) in our century are repetitions of the salient points in all past times, and probably in all countries." To prove this he must produce evidence of a constantly recurring period in Egypt, of an identical period in Australia, and so on, independently. This he has not done.

I myself have examined certain weather statistics, published in Vols. XVIII. and XXI, of the "Smithsonian Contributions to Knowledge," which refer, in one case, to the 'Precipitation of Rain and Snow,' and in the other, to the 'Average Temperature, over a considerable part of the United States of America. These volumes I lay before you to-night. The first table shews minima in 1818-9, 1836-7, 1856—just enough agreement with a nineteen years' cycle to tantalize but the other minima do not conform to such a cycle, nor do the maxima. In the second table minimum temperatures occur in 1785, 1797, 1816, 1835, 1857, 1868, and maxima in 1793, 1802, 1826, 1845, 1865. Mr. C. A. Schott, who compiled these tables says, "the average of the longer waves is about twenty-two years." I would point out that such an average does not assist Mr. Russell in any way, but quite opposes his conclusions. He refers to the moon as the "exciting cause," and he presumably has in his mind therefore the Metonic cycle of two hundred and thirty-five lunations, which gives a period of nineteen years so exactly, that an average error of even a few months is out of the question.

This Metonic cycle of nineteen years has been known to the astronomers of the civilized world for more than 2000 years. Greeks, Romans, Egyptians, all were acquainted with its undoubted accuracy. Surely, if this same cycle obtained as regards the annual overflow of the Nile, it would have been known to every Fellah in Egypt for the last 2,000 years. Such knowledge, once gained, could never be lost. The prosperity or adversity of the whole country depended upon this yearly flood; its approach was heralded to an expectant populace by swift messengers; its absence spread misery throughout the land. I conclude that it is highly improbable that a nineteen years' cycle has existed for the Nile-flood within historic times.

It is impossible to deal seriously with the evidence which Mr. Russell draws from Biblical meteorology. The dates given in the margins of some English bibles are foreign to the text, and have no scientific value. Supposing the dates are trustworthy which Mr. Russell gives from Greek and Roman history, they frequently seem to miss his datum line by from one to four years, and Mr. Russell's cycle is so full of different droughts that it seems easier to hit a drought somewhere than to miss altogether. He actually says in one place "It is worth mentioning that in India from 503 BC. to 443 BC. there was great drought and pestilence, and these dates are in the **D** series." It seems to me that a continuous sixty years' drought would completely efface three cycles and part of a fourth.

The picturesque description which is given of the peculiarities of a drought in New South Wales is no doubt quite accurate ; but it does not help the argument, and I can only conclude by saying that Mr. Russell has produced no satisfactory evidence that a nineteen years' cycle exists in the weather of the world. Not withstanding this conclusion, I think Mr. Russell has provided us with an extremely interesting paper, and I hope that these remarks upon its subject-matter do not exceed the limits of fair criticism.

Mr. D. M. MAITLAND, said that in a country dependent almost entirely on its pastoral and agricultural interests, the question of periodicity of seasons was of vital importance. There were some points in the paper, or rather in the diagram illustrating it, that he thought required further explanation. The year 1857 was shewn as about the middle of a dry cycle, of the **D** series, but on the coast at any rate the rains were very heavy ; in June, July, and August of that year, there occurred the highest floods of which any authentic records had been kept up to that time, those present might remember that the "Dunbar" was wrecked in the August of that year. Again in 1866, the year the "Cawarra" was wrecked, which is shewn as a dry year in an **A** cycle, very heavy floods occurred. The year he desired to call attention to particularly was 1867, (shewn in the middle of a dry cycle) of which the rainfall record at the Observatory was sixty-nine and a half inches, at Melbourne the same year, the rainfall was above the average, and if his memory served him correctly, the register

at Greenwich also shewed a rainfall higher than usual. That year would long be remembered in this Colony, from the fact that the most disastrous flood ever experienced in the valley of the Hawkesbury took place, the water rising at Windsor to a height of sixty-two feet above ordinary level. That year being apparently an exceptionally wet one, he would like to know whether its insertion in a dry cycle was an error or whether the records from other places indicated that the rain supply was so scanty elsewhere as to justify its insertion in a dry term, notwithstanding the large rainfall in Sydney, Melbourne, and in England.

Mr. P. N. TREBECK,said that the existence of a nineteen year cycle had been referred to by the late Rev. W. B. Clarke, as would be evident from the following extract from the Sydney Morning Herald of 1st May, 1846:—"The Rev. W. B. Clarke in a recent communication to the Sydney Herald, expresses his opinion that Sturts' desert, Leichhardt's experience of little or no rain even in the tropics, Sir T. L. Mitchell's sufferings on the Bogan from want of water, and the state of the Colony generally, prove this to have been a year of drought parallel with the season of 1826-7, and certainly adding another link to the chain of facts for establishing an atmospheric cycle of nineteen years."

Prof. THRELFALL said:—Mr. Russell's statement as to what constituted a good or a bad season is somewhat indeterminate.

(1) An exact definition of the difference between a drought and a good season was essential, otherwise there must be a fundamental uncertainty in the investigation. A farmer or pastoralist may be supposed to do well or ill according to a variety of circumstances, amongst which rainfall is no doubt a prominent but not overpowering factor.

(2) The records of Australia have, as I understand, only been kept with anything like adequate care for about five and twenty years, while the period decided on by Mr. Russell is nineteen years. Hence the observations have not really extended over more than a period and a third, and this is rather too little to form a foundation for such a wide generalization. Before the records were kept properly, the evidence as to 'good' and 'bad' years may have involved other than meteorological factors.

(3) With regard to the historical evidence advanced in which

droughts are cited sometimes from Europe, sometimes from India, leaves it uncertain whether there is a drought somewhere every nineteen years, or whether droughts recur at the same place every nineteen years.

(4) The statement in the paper, that Egypt like Europe seems to get its change of weather a year earlier or later than Australia, should appear in the historical evidence as drawn indifferently from Europe and India and run on the Australian records.

(5) These criticisms apply to droughts of the **A** series only. The evidence for the other series is on Mr. Russell's own shewing not sufficient to establish any periodicity at all.

(6) Whether the cycle of nineteen years be accepted or not, I consider that Mr. Russell's investigation has brought many interesting points to light, and that the method of comparing evidence collected from all parts of the world, exhaustively employed, can not fail to advance our knowledge of meteorology, and that Mr. Russell is to be complimented on having made such a plucky attack on a difficult subject.

Mr. CARMENT said that he would like to ask Mr. Russell whether his contention was that droughts prevailed over the whole of the world at once in accordance with the nineteen years' cycle; and whether or not he contended that the eclipses of the moon had any real connection with the atmospheric changes which were concerned in producing droughts. He would also like to ask why the vertical red lines in the diagram were drawn after the end of the first year of each of the **A** droughts, seeing that the successive intervals would have been just the same if they had been drawn at the commencement of the drought in each case. Again, it was not at all clear from the paper what had induced the author to construct precisely *five* different series of droughts and neither more nor less. It was clear that with a sufficient number of different series, each of which might last for several years, *any* previously recorded drought would fit into one or other of the given series. Further, the author had not given any data in his paper which would enable an independent observer to come to a conclusion as to the propriety or otherwise of any given year being classed as a *good year* or a *bad year*; and as regards the various historical droughts cited, one would require much more extensive information, as to the *nature* and *value* of

the evidence available in support of the alleged facts set forth, before being able to accept them as a foundation on which to base any theory of periodicity. In regard to the question of chronology alone and with respect to events which happened in prehistoric times, Mr. Russell had himself admitted that the dates were quite uncertain, and yet proceeded to found conclusions upon them in support of his theory.

Professor DAVID said that, with regard to Mr. Russell's nineteen year weather cycle he had collected some statistics as to the times of occurrence of some historic earthquakes and violent cyclones, the dates of which were authentic, with a view of ascertaining whether they supported the nineteen year weather cycle. The dates of the events referred to range from 1692 A.D., the great Jamaica earthquake, to 1886 A.D. the date of the eruption of Tarawera. Out of the fourteen events here recorded, three were violent cyclones in the Bay of Bengal, unaccompanied by earthquakes, one a violent cyclone in the Bay of Bengal accompanied by an earthquake, and the remaining eleven violent earthquakes. Of the four cyclones of phenomenal violence and extent one was at the commencement of an "**A**" drought, (so called in Mr. Russell's paper), one at the end of an "**A**" drought, one at the middle of a "**D**" drought, and one during an "**E**" drought. Of the twelve violent earthquakes, five were during or very close to a "**D**" drought, three occurred during an "**A**" drought, and four do not appear to have been connected with any of the drought periods referred to by Mr. Russell. Although the evidence might be considered inconclusive, it appeared probable that great cyclones and violent earthquakes were more frequent during droughts than at other times. Several of them fell into the "**A**" and "**D**" droughts, though this does not necessarily support the nineteen year cycle.[1]

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1 The possible relation between droughts and earthquakes may be explained as follows :—The earth is at present constantly radiating heat into space, and secular contraction results from this loss of heat, and secular contraction is probably the chief cause of earthquakes, through the earth's crust at a depth cracking owing to excess of tension. If the annual temperature over the whole earth's surface be raised, outflow of heat would be checked, and earthquake action would be at a minimum. Conversely, if the annual temperature be lowered the escape of telluric heat is accelerated, and

Mr. DEANE said:—Will Mr. Russell kindly inform me where the statement is to be found as to the number of large dead trees which were seen when colonists first landed here? I am much interested in the subject and would like to read the original account of it.

It is somewhat difficult to understand how a meteorological cycle can exist unless accompanied by or resulting from some cosmic cycle. Mr. Russell's cycle of nineteen years corresponds with the Metonic cycle, and a good may persons would be glad if Mr. Russell would explain what that term means. They believe that in a vague sort of way, it implies a recurrence of similar lunar phenomena, but are the phenomena which recur of sufficient importance to account for periodic variations of weather conditions?

I gather from Mr. Russell's remarks that similar eclipses recur at the same time of year after a period of nineteen years, and that when they take place near the equinoxes, droughts seem to result. If the period is an exact one, the centuries can be divided up indefinitely, if not, there must be a gradual transition in the character of the lunar phenomena which ought to be accompanied by an alteration in the meteorological maxima and minima.

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earthquake action would attain a maximum intensity; thus theoretically, earthquake action should be more intense in winter than in summer. Mallet's Curve for 5879 earthquakes in the Northern Hemisphere shows that they attained their maxima in January and October, and their minima in June. Out of two hundred and twenty-three earthquakes observed in the Southern Hemisphere the minima were in May and August and the maxima in November, May, June, and July, (as stated by Mr. J. Milne in his "Earthquakes and other Earth Movements."—*International Science Series*, p. 256, *London*, 1886). It would appear therefore that during the winter months in either hemisphere, earthquakes attain a greater intensity than during the summer months. If this is due to the cold of winter, and if commercial droughts are also droughts in the scientific sense, that is periods when the earth receives less superficial heat, and therefore makes less rain than at other periods, it should be possible to correlate maxima of earthquake intensity with drought maxima. The question, however, is much complicated by the slowness with which certain rocks conduct solar heat downwards, which prevents the wave of summer heat at a particular locality penetrating many feet into the ground until the following winter.

Does not the occurrence of eclipses depend upon the position of the moon's nodes? My difficulty is that the period of revolution of the moon's nodes does not correspond with the Metonic cycle. Which period is it that causes the meteorological phenomena?

If the moon has an influence on the weather it can only be by combining its pull on the atmosphere with that of the sun. When eclipses occur, the sun, moon and earth are in the best positions to produce the maximum effect, and when these occur near the equinoxes we might expect to see some special result, if at other times the sun, moon and earth were a long way off the straight line, but they never are at new and full moon more than 5° off the straight line, and of course generally much less ; would such a small difference in angular distance make such a large difference in meteorological effect?

If the result of the combined pull of sun and moon at these particular periods is strong winds, producing droughts in this and some other parts of the world, the increased force of the moist south-west Atlantic air-currents would probably cause a greater deposition of moisture in Western Europe, but it really seems, judging from recent experience, as if droughty weather in Australia is contemporaneous with droughty weather in Europe.

I was much struck with Mr. Russell's array of facts, but the method of deciding whether a particular year belonged to a drought or a good period was not quite clear to the audience, many of whom probably thought that a year with a rainfall up to, or nearly up to, the average, could not be a droughty year, disregarding ; however, the irregularity with which the rain fell. A definition of the word drought as applied to this country is very desirable, so that observers might be able to classify the weather with some certainty.

The PRESIDENT asked what convention Mr. Russell adopted to indicate with an approximation to uniformity, the beginning and end of a drought, for the purpose of graphic illustration.

Mr. RUSSELL in reply said :—Professor Gurney asks,

(1) " What is Mr. Russell's definition of 'a good year or a bad year' ?" The terms good and bad were defined in the paper as those having " sufficient or insufficient rainfall." In the text, page Error: Reference source not found, I had shewn by reference to

1895, what a bad year was, and stated "Drought is not wholly made by a shortage of rainfall, its most important factors are great heat and drying winds." I should like to give all the data. on which the diagram was based, but it would cover at least two volumes as large as our annual one, and it could not therefore be included in a paper such as this, and I thought, perhaps I was mistaken, that I could be trusted to go through these records and, select the good and bad years. Moreover, I had gone over it once before, and published it in an abstract. My reason for going over it again was to include all the additional matter.

(2) Professor Gurney objects to my making a definite point in a drought, by drawing a line between the first and second year, and points out that it might be drawn anywhere. It may be said here in reply to several questions, a drought is difficult to get hold of, because its limits are not sharply defined like a month or a year in which a day comes, that you pass by the stroke of the pendulum to the next one, it is wanting in defined limits, often drought and rainfall battle for months so evenly, that it is difficult to draw any line, and therefore I took the middle year as the date of the drought; drawing the line between the first and second year, simply to avoid making another line across the record. Now a glance at the diagram shews that out of six **A** droughts on record four lasted three years or thereabouts, and the second year was therefore at least the nearest to the middle of the drought.

(3) "Periodicity cannot be shewn by picking out a drought here and there." Certainly not, but I have not done so. It is stated in the text that history had been asked for data, which it had been in the habit of neglecting, and that this was admitted to be a weak point, the difficulty of obtaining the data. But it is a very strong point to be able to say, as was done in the text, that all the historical data that I had been able to find in twenty years study, is in favour of the nineteen years' cycle. To my mind this is one of the strongest proofs of the cycle, and I think in legal matters, when all the evidence points to one conclusion, the jury is satisfied, even if the evidence is not complete in every point. If it were necessary to prove constantly recurring periods in Egypt, there would be small hope, but is it? The records of the past Nile levels seem to have all disappeared, except for a short recent period, which, as stated in the text, are very strongly in favour of

the cycle, and I must disagree with Professor Gurney's argument that such knowledge once gained in Egypt would never be lost, for the knowledge was not gained by the common herd who survived the downfall, it was known only to the priests, and would in all probability have been lost in the centuries of degradation through which Egypt has passed.

(4) The evidence quoted from Smithsonian Contributions of Knowledge. The minima of snow and rain (*i.e.*, droughts) were in 1818-9, 1836-7, 1856 in America. Let us see how they compare with the diagram; 1818-9 were in **D** drought here; 1836-7 **D** drought here began in the latter part of 1836, lasted all 1837 and 1838; 1856, **D** drought here began in the latter part of 1856 and continued through 1857-8. The evidence here is far stronger in favour of a connection between these North American droughts and the Australian nineteen years' cycle than against it, the more so, when we remember that there is good reason to believe from the records, and from common observation, that the change to drought or to wet weather there is generally a year in advance of the date in the Southern Hemisphere. I have not gone into the question of minimum temperature at all, but of the dates of five maxima in America, three agree closely with our droughts which began in 1826, 1845, and 1865. It is evident therefore, that had Professor Gurney looked a little more closely he would have found confirmation not contradiction.

(5) Now as to what the Professor calls " Biblical Meteorology" "which it is impossible to take seriously," the point cannot be passed over so lightly. I know in common, I suppose, with every one who has read anything about chronology, that the dates in question are generally taken to be guesses at the probable dates, an uncertainty which I indicated at the time; but the facts remain, first, that whatever the chronologists did, the intervals between those droughts and ours are multiples of nineteen years, within the limits of the droughts; and second, that the intervals amongst them are either exactly nineteen years or multiples of nineteen years; the same remarks apply to the other B.C. droughts. I rejected one of them, and gave the reason for doing so: the remaining seventeen all support the nineteen years' cycle. The drought in India 503 BC. to 443 B.C. when we come to look into it, is not such a remarkable occurrence, for we find from the

carefully kept meteorological records of England, that last century, *i.e.*, from 1738 to 1762 a period of twenty-five years, there was a drought in England, in which the average rainfall for the whole period was only 78% of the average ; four years of this period, 1740-41-42-43 were exceptionally dry, the rainfall only amounted to 63% of the average, and perhaps it will seem remarkable, but according to the nineteen years cycle, part of 1740, all 1741-42 and part of 1743 must have been a drought in New South Wales. Again other four years of the English period 1759-60-61-62 made a drought with an average percentage of rain of 76 or 24% below the average, and again we find the computed drought for Australia part of 1759, all 1760-61, and part of 1762. It is obvious therefore that there can be long periods of drought in England as in India, and that in them there may be intensified periods of the drought, the dates of which would be chronicled and fit into the nineteen years' cycle. These facts seem to me to be strongly in favour of the nineteen years' cycle instead of against it as the Professor thinks.

(6) The Professor says, "the cycle is so full of different droughts that it seems easier to hit a drought somewhere than miss altogether." I collected many facts about these minor droughts, and have good reason to believe that I could, for some short intervals, shew that the great and little droughts in the northern hemisphere could be shewn to be in the same order and relation as they are in Australia, but I thought that there was not evidence enough to be convincing, and I omitted them as they were not material to my purpose, and took the two major droughts, and have proved that they have recurred very frequently in their order. Had I taken one only, it would have been enough for my purpose, *i.e.*, to prove that a certain phase of weather recurs, but I did take only the two major droughts about which history has something to say.

(7) Mr. Carment asks if I contended that droughts prevailed over the whole of the world in nineteen years' cycles? That was what I meant to convey as my conviction, but as pointed out, nearly the whole of the world had no history of such matters, and it could not at present he proved. See list of droughts under date 1876, appendix 2.

(8) As to the effect of eclipses of the sun and moon on

weather. I said in the text that the investigation as to the moon was unfinished, but that, so far as the comparison of the moon's position, in relation to the sun and earth and droughts, goes, it shews that when the eclipses occur about the equinoxes, that is, when both sun and moon are making the greatest tides in the ocean, then we have droughts, due possibly to their combined influence on the earth's atmosphere.

(9) Mr. Carment—"It was not clear from the paper what had induced the author to construct five different series of droughts." A reference to the text shews that I did not construct them. The years were studied and classified without reference to any cycle, and when this was done, the diagram was complete with its good and had years all shewn, the theory followed to account for the order in which they recur.

(10) As to what constituted a good or bad year, see (1) in reply to Professor Gurney. And in regard to the statement that it did not appear why the author had constructed five different series of droughts, see my reply

(11) And as to the question of chronology see (5).

(12) Mr. Maitland, I think correctly appreciates the importance of the nineteen years' cycle, but does not see how great rains and floods form parts of droughts. In the text I have endeavoured to shew that places with large rainfall, as the coast of New South Wales, do not feel the severity of drought, and that hurricane storms are in some way connected with droughts, and such storms travelled down our coast in 1857 and 1866 depositing deluges of rain on the coast, while inland drought reigned supreme; these are the phases of what I have called in the text "breaks in droughts."

(13) Mr. Trebeck's quotation is support from a very close observer of nature, and could we find a full statement of the late Rev. W. B. Clarke's opinions on this subject they would be invaluable.

(14) Professor Threlfall's criticism (1) is I think answered in my reply (1). In answer to (3) and (4):—No, the complete meteorological records go back only twenty-five years, but newspapers and histories have enabled me to carry the record back to the foundation of the Colony, see my replies (1) and (3).

(15) Professor Threlfall (5), said his criticisms apply to drought **A** only. The evidence for the other series is on Mr. Russell's own shewing, not sufficient to establish any periodicity at all. This does not represent my contention; I claim that droughts **A** and **D** are in the nineteen years' cycle, the others I did not discuss; see my reply (6). History seldom records any but the major droughts **A** and **D**. The recurrence of these in a nineteen year cycle is I think, proved beyond question, if the fact be remembered that there was in past ages no meteorology, and a record of drought only when very intense, or the cause of some disaster. If these occasional records ALL prove the cycle, as I have shewn that they do, then the probability in its favour is so strong, that, to my mind it is proof of the fact.

(16) Mr. Deane asked, where the story about dead trees was to be found. References to this fact in my book on the "Climate of New South Wales," 1876, pp. 66 and 181 :—(Royal Society, N.S. Wales, Vol. x., p. 165, 1876.)

A full reply to Mr. Deane's further questions can only be given on the completion of the investigation into the cause of droughts, and I regret that this is not far enough advanced to enable me to reply; evidence sufficient to. convince me as to the moon's influence has, however, been obtained, as indicated in the text, and I hope that when completed it will amount to a demonstration; I may, however, say here, that I do not think eclipses, as such, have any appreciable influence on droughts.

The President asks, "What convention Mr. Russell adopted to indicate with an approximation to uniformity, the beginning and end of a drought for the purpose of graphic illustration." The only guide as to the boundary line between good and bad years was the time when sufficient rain ceased, which marked the end of good weather, which as the diagram shews was very frequently not the end of a year, but often was the time of equinoxes; sometimes the change comes in other months, but the tendency is for a change to come about March or September, the times of equinox; when thus determined, the diagram was plotted accordingly, shewing as nearly as the size of the diagram permitted, the time of year at which the change took place.

The Rev. Dr. Wyatt Gill, who was for thirty-three years a

missionary in the Cook's group of Islands, and knew from his predecessor, what the weather had been for seven years before he went, gives me as his contribution to the discussion on my paper: some valuable notes as the result of that forty years experience. He says, that in those islands hurricanes came in droughts, and 'he knew that they were in for a hurricane if there was a drought in summer,' and the natives of Mangaia, who are keen observers, if asked about the weather repeated their proverb, "*Kare e roto, ka ta to aa ra*," which translated is, "should there be no flood there will be a hurricane." This then was the result of generations of close observation by those whose lives to a large extent depended upon it. Unquestionably a heavy flood in those islands is a *far less* evil than a cyclone, because the flood secured sufficient moisture for the "Taro"[1] which constitutes the staff of life on Mangaia, and at that period no supplies of food were obtainable from any outside source. About the year 1813 a terrible famine resulted from long continued drought in the island of Mangaia. Probably a half, certainly one-third of the population died in consequence of that drought. In December 1831 a most severe cyclone was experienced at Rarotonga and Mangaia: on the island of Rarotonga 1,000 houses were destroyed. In March 1846, a fearful cyclone took place desolating the entire group of islands. On March 27, 1866, another fearful cyclone devastated Mangaia, destroying two hundred and sixty-eight houses and uprooting 2,000 cocoa-nut palms; Rarotonga suffered in the same cyclone, but not so severely as Mangaia.

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1 Caladium petiolatum.

The Periodicity of Good and Bad Seasons.

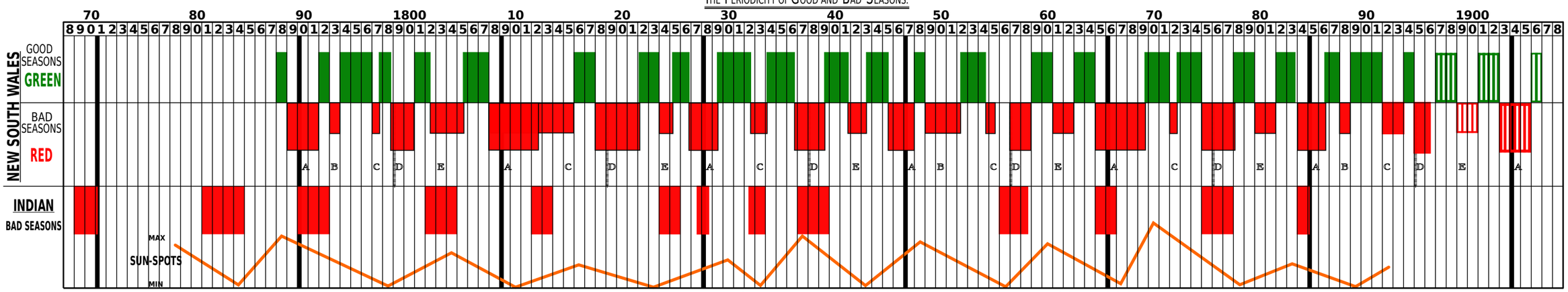

Diagram shewing Good and Bad Seasons in **NEW SOUTH WALES** from 1788 to 1896
also Bad Seasons in **INDIA**
Maxima and Minima of Sun-Spots

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE
SYDNEY, NEW SOUTH WALES